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The Influence of Different Activities on the Apparent Length of Time

By

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Psychological Monographs: General and Applied

THE INFLUENCE OF DIFFERENT ACTIVITIES ON THE APPARENT LENGTH OF TIME[1]

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IT IS A COMMONPLACE of daily experience that time seems to pass more rapidly under some conditions than it does under others. And yet such familiar phenomena as the slow passage of time in boredom, depression, or suspense, or its rapid flow when the attention is pleasantly absorbed, have not been greatly clarified at the hands of psychologists.

One reason for this may well be that the experimental manipulation of variables of attention and attitude is uncertain at best. This situation is aggravated by the fact that many investigators of temporal perception have preferred to work with intervals only a few seconds in length, which offer many advantages in terms of psychophysical elegance but little scope for the manipulation of mood.

On the other hand, the investigators who have worked with longer intervals, although they have amply confirmed that time will appear to differ in its rate of passage under different conditions, have varied so widely in the conditions they have chosen that it is by no means certain whether the concepts invoked by one are applicable to the results of another. A few examples may serve to make this clear.

Harton (1938) found that subjects making difficult weight discriminations estimated the time to be shorter than during an equal period spent making easy discriminations. Axel (1924) found that subjects estimated a period spent solving analogies as shorter than an equal period spent canceling 5's. Rosenzweig and Koht (1933) found that subjects estimated a "test" period with an insoluble puzzle as shorter than an equal "practice" period. On the face of it, one might suspect that these three results had a considerable amount in common, but the three authors offer quite different concepts to interpret them. Axel speaks of higher and lower levels of behavior, Harton of unity of organization, and Rosenzweig and Koht of need-tension.

Other experimenters have had their subjects estimate the time spent taking dictation, listening to a person read, listening to music and metronomes, canceling letters, stringing beads, submitting to pain, noise, and electric shock, solving puzzles and mazes, making public speeches, reading aloud, filling out questionnaires, and just resting. And in addition to the concepts mentioned above, they have, in interpreting their results, used such terms as filled and unfilled time, concentration, level of attention, kinesthetic strain, satiation, stress, self-organization, attractiveness of or distance to a goal, and so forth.

It seems unlikely that all these concepts are necessary to interpret the experimental

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[1] This paper is a portion of a dissertation submitted to the Department of Psychology of the University of California in partial fulfillment of requirements for the degree of Doctor of Philosophy.

It is with pleasure that I acknowledge the helpful counsel of my thesis director, D. W. MacKinnon, and the other members of my dissertation committee, C. F. Wrigley and W. R. Dennes. In addition, I owe a particular debt of gratitude to R. S. Crutchfield for valuable discussions during the formulation of the project.

For making possible the electronic computations, I am grateful to the Operating Committee and staff of the University of California Computer Center, and to the National Science Foundation, which contributes to the support of the Center. I would also like to express my thanks to Jay Adams, J. O. Neuhaus, and William Murr for their advice and assistance in connection with the computations.

[2] Now at the University of Nebraska.

findings. And yet it seems doubtful that any one of them is sufficient. The first task of the present investigation was, therefore, to determine how many and what kinds of variables are necessary in order to account for variations in the apparent length of time, in situations of the kind which experimenters in this area have traditionally been concerned with.

Given such variables, further questions arise concerning their generality. Are they equally important for various lengths of interval? It seems likely that some influences on time perception in longer periods are equally effective during short intervals, and that others are not. Different methods have been used in experiments in time perception: To what extent are the same variables involved regardless of the method of measurement? And finally the question always arises: How important are such experimentally derived variables in dealing with time perception outside the laboratory? The present investigation did not attempt to deal comprehensively with all these questions, but it did endeavor to gain at least preliminary information along each of these lines.

Design of the Experiment

The first goal of the present research was to determine what different kinds of influence the contents of time intervals have on the apparent duration of the intervals. One sort of evidence for believing that different situations are similar or different in their effect on time estimation is the degree of correlation between persons' time estimates in the situations. If individuals are similarly ordered in Situations A and B in terms of the length of their time estimates, but differently ordered in Situation C, one has some grounds for supposing that A and B are affecting the estimates in the same way, and that C is having a different influence. Given a number of such situations, and the corresponding correlations, it should be possible to gain some notion as to how many different influences are operating, and what kinds. In the present investigation, the technique of factor analysis seemed the obvious method to use for this purpose.

Since, in such an analysis, the factors obtained are ultimately derived from the way situations affect persons, they may reflect both characteristics of the situations and characteristics of the persons. In some uses of the factor analytic technique, interest is focused primarily on one or the other of these. The literature of time perception suggests, however, that in this area we may be dealing quite directly with differences in the way situations affect persons. Therefore, in the present design, provision is made for varying the situations in which time is judged, for evaluating some characteristics of the persons doing the judging, and for determining several aspects of the persons' perceptions of the situations.

It should be noted that an approach of this kind depends on individual differences. A variable that affected all persons in exactly the same way would not influence the correlations between situations, and hence could not emerge as a factor in the analysis. While a complete absence of individual differences is hardly to be expected, tendencies toward greater or less uniformity presumably exist, and could well affect the weight certain variables have in a factor analysis—a possibility to be kept in mind in interpreting the results.

The 2-Minute Tasks

The basic part of the experiment was the obtaining of estimates of the duration of a 2-minute time interval occupied in a variety of ways. The conditions were selected with several criteria in mind, including the following: (*a*) they should provide a good sampling of the kinds of conditions known from earlier research to affect time estimates; (*b*) they should afford a minimum of irrelevant cues to length—the *S*s should be given as few grounds as possible for comparing different tasks on such bases as the proportion of the task accomplished, number of items done, etc.; (*c*) some periods should be included which the *S*s would not expect to estimate; (*d*) some of the tasks should provide scores on other dimensions which might be relevant to time estimation; and (*e*) the tasks should be suitable for group administration.

The following conditions were selected. They are listed in the order in which they were administered.[3]

1. *Introduction.* A 2-minute period occupied by *E*'s introduction of the experiment, the distribution of test booklets, filling in of face-sheet data, etc.

2. *Writing 1's.* The *S* wrote the figure "1" repeatedly on a blank sheet of paper.

3. *Easy anagram.* The *S* made words out of letters from a given long word (TRANSPORTATION).

4. *Difficult comparisons.* The *S* made psychophysical judgments—comparisons of pairs of short time intervals.

5. *Gottschaldt practice.* The *S* solved hidden-figure puzzles "for practice."

6. *Gottschaldt test.* The *S* solved similar puzzles, as a "test."

7. *Slow calculation.* Cumulative mental addition and subtraction of numbers from 1 to 5, called out at a slow rate by *E*.

8. *Listening to reading.* The *S* listened while *E* read aloud a passage of humorous prose.

9. *Pleasant thoughts.* The *S* was instructed to close his eyes, relax, and think about any pleasant topic.

10. *Interruption.* An apparent apparatus breakdown, which required two minutes for *E* to "repair."

11. *Writing 1's.* Repetition of No. 2 above.

12. *Easy comparisons.* Repetition of No. 4, but quite easy comparisons.

13. *Difficult anagram.* Repetition of No. 3, but a more difficult word (MISSISSIPPI).

14. *Counting "the's."* The *S* counted occurrences of the word "the" in another prose passage read aloud by *E*.

15. *Concentration on time.* The *S* was instructed to close his eyes and concentrate on the experience of the passage of time.

16. *Questionnaire.* The *S* was occupied in responding to the items of a questionnaire concerning his everyday time perception.

The activities were all of the same length —two minutes—to permit direct comparisons among them. In preliminary tests it appeared that the variation of the apparent length of the intervals was sufficiently great that almost none of the *S*s had any suspicion of their objective equality.

The activities were administered in the same order to all *S*s: first, for considerations of experimental convenience, and second, because it was undesirable to change the positions of some of the items—e.g., *Concentration on time* had to be given toward the end to avoid possible contaminating effects on the other estimates, and *Introduction* was of necessity given at the start. The fixed order did, however, introduce certain complications (see the interpretation of Factors I and III below).

The Nature of the Estimates

In previous studies of intervals of moderate length, a direct estimate in conventional time units has usually been used. As contrasted with comparison or reproduction methods, this method has the advantage that the estimates are both more readily made and more simply interpreted. With techniques in which two intervals are compared it is always a problem to determine which of the intervals is being affected in a particular instance—if the second is judged the longer of the two, is it because it is being overestimated, or because the first is being underestimated, or because both things are happening, or because both intervals are being over- or underestimated to different degrees? Decision among these alternatives often presents thorny problems. The main disadvantages of the direct estimate method, on the other hand, are (*a*) the fact that the distribution of estimates tends to be skewed by the proximity of the zero point, particularly if the intervals are short, and (*b*) the tendency of many subjects to give "round number" estimates—to favor estimates of whole minutes and simple fractions of a minute.

Since neither of these tendencies, in a moderate degree at least, would be too serious in the present investigation, the method of estimation in conventional time units was adopted. The *S*s were asked to make their estimates to the nearest ten seconds. With the expected range of judgments, this would provide satisfactory discrimination, and it was hoped that this unit would be large enough for *S*s to actually use, whereas asking for an estimate to the

[3] A detailed description of the experimental procedures, including instructions to *S*s, may be found in Loehlin (1957, pp. 45–58).

nearest second, as is usually done, almost inevitably drives *S* to a higher-order unit such as the quarter- or half-minute.[4]

In previous investigations using the method of direct estimation, *S*s have usually simply been asked to estimate how long a given interval was. But this presents problems. There are a variety of possible determinants of the estimate *S* makes of a time interval, and how long the interval seems to *S* is only one. Assuming that the experimental arrangement is successful in avoiding gross give-away cues, the most important additional variable will probably be *S*'s belief as to whether, under the given conditions, time is likely to seem longer or shorter to him than it really is. During preliminary experiments in the present investigation, it became clearly apparent that many *S*s will, in fact, make allowances of this kind when asked to estimate the length of intervals of time. If the interest of the experimenter is simply in how well *S* can estimate time under various conditions, this presents no problem. But if his concern is with how the conditions affect *S*'s perception of the time, the matter must be dealt with.

The solution adopted was to have *S* make *two* estimates—one of how long the time seemed, and one of how long he thought it actually was. The procedure is somewhat analogous to the "perceptual" and "critical" attitudes used by Brunswik (1949) and others in the study of constancies and other perceptual phenomena. It was hoped that *S*'s judgment of how long the time seemed would follow fairly directly from his perception of it, while any deliberate inferences based on his knowledge of the situation would be confined to his estimate of how long the time actually was. The estimate of how long the time seemed was always made first and put in a "box" on the response sheet. The estimate of how long the time actually was was made afterwards and written outside the box to emphasize its derived character. The *S*s were not forced to make a distinction; the instructions permitted both estimates to be the same. For a few *S*s the distinction did seem to be a meaningless one.[5]

After making the two estimates, *S*s rated each task on five 5-point scales. They indicated whether the activity seemed interesting or boring, difficult or easy, satisfying or frustrating; whether the time seemed to pass slowly or rapidly; and whether they wished the period had been shorter or longer.

Other Time Judgments

Along with the judgment of 2-minute intervals, some estimates of shorter and longer intervals of time were included, and some comparisons of short time intervals. The main purpose of these additional measures was to gain generality—to determine whether the ways in which content influenced the estimation of the 2-minute intervals would affect a wider range of times, and whether these influences might also contribute to certain other phenomena in the area of time perception, namely, time errors and other illusions occurring in the comparison of short time intervals.

Two short periods of time were included: one second and four seconds. Four estimates were made of each of these two intervals, the estimates being spaced among the other procedures. The *S*s were instructed to make their estimates to the nearest tenth of a second. No distinction was made between how long time seemed and how long it was on the assumption that this distinction would not be very meaningful for such short periods, particularly the 1-second interval.

To provide an estimate of a longer interval, a 20-minute period was used (the first 20 minutes of the experimental session). This particular interval was selected as one that was long enough to be clearly of a different order from the 2-minute period, without being so long as to approach the larger known interval in which it was embedded, the 50-minute class hour. The *S*s

[4] This hope was only partially realized. A good many *S*s used higher-order units anyway.

[5] For some evidence suggesting that the procedure had the effect desired, see Loehlin (1957, pp. 72–78).

made estimates both of how long the interval seemed, and how long they thought it actually was.

Two procedures in which short intervals were compared were also chosen for inclusion. In one of these, pairs of empty intervals were compared in order to measure the time error. Eighteen trials were used; in each a standard 4-second interval was presented first, followed by a comparison interval which varied from 2½ seconds to 4½ seconds, with the largest number of trials in the neighborhood of 3½ seconds. (A negative time error was anticipated.)

For the other comparison procedure, one was chosen in which the two compared intervals actually differed in their content. The technique used by the writer in an earlier, unpublished investigation was employed. An accelerating pattern of four sounds was compared with a decelerating pattern (a comparison of the form . . . . . .). Each pattern was of the same total length — again four seconds — and twelve comparisons were made, half in each order.

Time Questionnaire

To provide the possibility of generalization of a different kind, *S*s were asked at the end of the experiment to fill out a questionnaire consisting of 85 true–false, self-descriptive items concerning their perception of and attitudes toward time in everyday life situations. (The questionnaire is reproduced in Loehlin [1957] as Appendix F.) The items for this questionnaire were mostly newly written, although a few were adapted from other sources, such as a questionnaire used by Adler (1954). An effort was made to include a variety of items from everyday experience, as well as items derived from aberrations of behavior and perception concerning time as reported in the clinical literature (e.g., Bonaparte, 1940; Dooley, 1941; DuBois, 1954; Schilder, 1936).

Other Measures

Several of the experimental procedures permitted the derivation of additional scores. It seemed desirable to represent at least two general areas of personal function. One was the individual's characteristic flow of activity, as represented by variables such as fluency, personal tempo, and the like. The other was his ability to perceive accurately in spite of distraction: to analyze out aspects of a complex perceptual situation.

For the area of fluency, scores were obtained for (*a*) the number of 1's written in two 2-minute periods (under instructions to write at a natural rate); (*b*) the number of solutions to the easy anagram; and (*c*) the number of questionnaire items completed in a 2-minute interval.

For measurements of the ability to perceive analytically, scores were obtained for (*a*) the Gottschaldt figures and (*b*) the "counting the's" procedure. In both these tasks, *S* must be able to isolate highly embedded features of the situation and to resist the distraction of irrelevant aspects.

The MMPI

Finally, as an instrument to evaluate differences of an emotional and motivational nature between individuals, the Minnesota Multiphasic Personality Inventory (MMPI) was chosen. The MMPI's were completed on a voluntary basis at a date several months after the main experiment, and were available for about 70% of the subjects.

Summary

To summarize briefly, the design of the experiment was as follows: (*a*) Obtain from a group of *S*s their estimates of how long time seems in a variety of situations, as well as estimates of different lengths of interval, measures of other time perception phenomena, and scores on other related variables. (*b*) Intercorrelate these measures and factor-analyze. (*c*) Interpret the factors thus obtained using knowledge of the situations, knowledge of the *S*s' ratings of the situations along various dimensions, and knowledge of the personality organization of the subjects. And finally, (*d*) consider the relationship of these factors to the findings of previous investigators in this area, and to the *S*s' reports of their

TABLE 1

NUMBERS OF *Ss*, BY AGE, SEX, AND PSYCHOLOGY COURSE

Course	Age						All Ages
	17	18	19	20	21	22	
Introductory							
Men	—	1	5	3	1	—	10
Women	—	7	13	4	1	—	25
Personality							
Men	—	1	3	4	2	1	11
Women	1	8	24	9	3	1	46
Industrial							
Men	—	—	—	1	8	1	10
Women	—	—	—	—	3	—	3
Totals	1	17	45	21	18	3	105

behavior, perception, and attitudes with respect to time.

COLLECTION AND ANALYSIS OF THE DATA [6]

Subjects

The *Ss* were 105 members of undergraduate psychology courses at the University of California at Berkeley, who participated in the experiment as part of a course requirement. They were obtained from the introductory psychology course, from a lower-division course in personal and social adjustment designed for non-majors in psychology, and from an upper-division course in industrial psychology. Psychology majors in the last-named class were excluded from the sample.

In view of the possibility that large variations in age may affect time estimation (Adler, 1954), *Ss* falling outside the range of 17-22 years were eliminated from the sample. (Swift and McGeoch [1925] found no relationship of age to time estimation in their experiment, with an age range approximately the same as that used in the present study.) The distribution of the subjects according to age, sex, and psychology course is shown in Table 1.

The *Ss* were tested in small groups, in a two-hour experimental session. The size of the groups varied from one to nine persons, depending on the vagaries of sign-ups, with about 80% of the total sample being tested in groups of four to eight persons.

Scoring

The following 28 measures were selected for inclusion in a matrix to be intercorrelated and factor-analyzed:

1–16. Estimates of the sixteen 2-minute tasks. ("How long time seemed.")

17. Estimate of 1 second—mean of Trials 2–4. (r_{tt} = .79)[7]

18. Estimate of 4 seconds—mean of Trials 2–4. (r_{tt} = .84)

19. Estimate of 20 minutes.

20. Negative time error, comparison of 4-second intervals—number of trials on which the second interval was judged longer, in *Difficult comparisons*. (r_{tt} = .50)

21. Amount of illusion, accelerating and decelerating patterns—number of trials on which the decelerating pattern was judged longer. (r_{tt} = .44)

22. Number of 1's written—two trials combined. (r_{tt} = .82)

23. Number of questionnaire items completed in two minutes.

24. Number of *Easy anagram* solutions in two minutes.

25. Number of *Gottschaldt figures* solutions in four minutes—practice and test periods combined. (r_{tt} = .83)

26. Error, *Counting "the's"*—discrepancy between *S*'s answer and the correct score.

27. Number of persons in *S*'s test group.

28. *S*'s age in years.

Factor Analysis

The scores were punched on IBM cards, and with the program of Beckman and Quarles (1956) means and standard deviations for all the variables (Appendix A), the matrix of Pearsonian r's of each variable with each other (Appendix B), and the inverse of that matrix, were computed by the IBM 701 electronic computer.

From the inverse matrix, the square of the multiple correlation of each variable with all the remaining variables was calculated, providing an estimate of the communality. Guttman (1954b) has shown that the exact communality will never be lower than this value, and Wrigley (1956) has found the squared multiple correlation to be a good initial estimate of the com-

[6] A more complete description of the treatment of the data may be found in Loehlin (1957, pp. 59–71).

[7] All reliabilities given are split-half, corrected by the Spearman-Brown formula.

munality, in an empirical comparison with a number of other methods of estimation.

The correlations and estimated communalities (to three decimal places) were then repunched on IBM cards and a principal axes factor analysis was computed by the IBM 701, using a program written by J. O. Neuhaus. The loadings for the twelve factors of greatest variance are given as Appendix C.

In choosing the number of factors to rotate, indications from several of the empirical and theoretical criteria cited in the literature were considered (see, e.g., Cattell, 1952, p. 298 ff). Most of these criteria were originally developed for the purpose of determining when to stop extracting factors when using the centroid methods, but similar considerations apply in the present situation. As is typical, the different criteria gave somewhat different indications. McNemar's criterion, which "tends in general experience to stop factorization too early" (Cattell, 1952, p. 300), dropped below its critical value after five factors. The Guilford-Lacey rule (Thomson, 1951, p. 122) gave its first value below the critical one for the fifth factor, but the sixth and ninth factors again exceeded the criterion. Mosier's requirement (Cattell, 1952, p. 299) of a leveling off of the standard deviations of successive sets of residuals might be taken to indicate the insignificance of all factors after the first, the third, the eighth, or some subsequent factor, depending on how narrowly it is applied. Saunders' criterion, which Cattell describes as probably the "theoretically and practically most effective" of the eleven he lists (Cattell, 1952, p. 301), did not pass its critical value until after nine factors.

After some exploratory rotations with a few factors, the first eight factors were selected for rotation. A graphical technique was used until the final position of the axes was approached, when a rotating matrix was computed and accurate loadings obtained algebraically. Then final graphical adjustments were made, the final rotating matrix derived, and the final matrix of factor loadings computed. (See Appendices C–E for the original factor matrix, the rotating matrix, and the final factor matrix.) The ninth and tenth factors were plotted against Factors I–VIII following rotation, to see if their inclusion in further rotation were merited. Factor IX failed to suggest any additional rotations; Factor X suggested only one (with Factor IV), and the indications for that one were somewhat doubtful. The addition of two dimensions of questionable significance in order to secure a possible improvement in the position of one axis did not seem justified.

The axes were kept orthogonal during rotation, not so much on the basis of theoretical preconceptions, as in the absence of any very strong indications for the abandonment of orthogonality. The first factor could reasonably be placed oblique to some of the rest; on the other hand, its retention in its present form, as a factor general to the 2-minute estimates, seems psychologically meaningful. The remaining factors show no indications of more than very slight obliquity among themselves.

The structure resulting from the present rotation meets all but one of Thurstone's (1935) original criteria of simple structure (considering a loading of less than .10 to be negligible [Thurstone, 1935, p. 156]). The deficiency is in an insufficient number of zero-order loadings on the first factor. The small number of variables in the hyperplane of this factor is attributable to the large number of 2-minute estimates in the matrix, since Factor I is general to these. The present structure is also satisfactory, again excepting Factor I, by Cattell's criterion of hyperplane area (1/3 to 1/2 the variables on each factor in the plus-or-minus .10 hyperplane [Cattell, 1952, p. 238]).

Factor Scores

A tentative interpretation of the rotated factors suggested that four (Factors I, II, IV, and V) would be of principal interest from the standpoint of time perception. Approximate factor scores were derived for these as follows:

Factor I. Two-minute estimates: *Difficult comparisons + Gottschaldt practice + Pleasant thoughts + Questionnaire.*

Factor II. 4 × estimate of 1 second + estimate of 4 seconds.

Factor IV. Two-minute estimates: *(Writing 1's (2nd) + Hard anagram) − (Writing 1's (1st) + Easy anagram)* + 50.

Factor V. (Negative time error, *Difficult comparisons* + Amount of illusion, *Accel.-decel. patterns*) reflected.

Intercorrelations of the four factor scores were computed, and the scores proved to be fairly independent, as desired. The only r's greater than ± .05 were $r_{I\,II} = .14$ and $r_{IV\,V} = -.16$.

Persons scoring in the highest and lowest 27% on each of these factors were selected for comparison of their ratings of the various activities and their MMPI scores. Each of these high- and low-scoring groups contained 28 persons.

MMPI

Five of the standard MMPI clinical scales, *D, Hy, Pd, Pt,* and *Ma,* were selected as being the most likely to be related to differences in time perception, and to these was added the Ego Strength scale developed by Barron (1953). The MMPI's of the 74 *S*s who took the test were scored on these scales in the standard manner (Hathaway & McKinley, 1946), including the *K*-correction. The validation scores were examined, and one *S* who obtained an *F* score of 17 was dropped from the sample, leaving 73 subjects.

For the groups of 28 high and low *S*s on each of the factors, MMPI's were available as indicated in Table 2. These differences are of an order attributable to chance. Thus while those *S*s for whom MMPI's were not obtained may have differed in some ways from those who took the test, it does not appear that these differences are significantly related to their time perception scores.

TABLE 2

NUMBER OF MMPI'S AVAILABLE, FOR *S*S WITH HIGH AND LOW FACTOR SCORES

(28 *S*s Per Group)

Group	Factor			
	I	II	IV	V
High scorers	20	21	20	16
Low scorers	19	16	21	21

RESULTS [8]

Interpretation of the Factors

Factors I and III. (See Tables 3 and 4.) Factors I and III have most of their load-

TABLE 3

VARIABLES LOADED ON FACTOR I

No.	Variable	Loading
9	2-min. est., Pleasant thoughts	.70
13	2-min. est., Hard anagram	.67
14	2-min. est., Counting "the's"	.64
12	2-min. est., Easy comparisons	.59
15	2-min. est., Concentration on time	.58
7	2-min. est., Slow calculation	.56
10	2-min. est., Interruption	.55
16	2-min. est., Questionnaire	.52
5	2-min. est., Gottschaldt practice	.51
4	2-min. est., Difficult comparisons	.50
8	2-min. est., Listening to reading	.49
3	2-min. est., Easy anagram	.48
6	2-min. est., Gottschaldt test	.41
11	2-min. est., Writing 1's (2nd)	.40
2	2-min. est., Writing 1's (1st)	.26
23	No. of questionnaire items in 2 min.	−.35
24	Easy anagram solutions	−.40

TABLE 4

VARIABLES LOADED ON FACTOR III

No.	Variable	Loading
6	2-min. est., Gottschaldt test	.63
5	2-min. est., Gottschaldt practice	.58
19	20-min. estimate	.46
4	2-min. est., Difficult comparisons	.38
2	2-min. est., Writing 1's (1st)	.38
3	2-min. est., Easy anagram	.34
1	2-min. est., Introduction	.32
23	No. of questionnaire items in 2 min.	.27
25	Gottschaldt figures solutions	−.28

[8] For a presentation of the results of the separate procedures, see Loehlin (1957, pp. 72–83).

ings on the 2-minute estimates, and all the 2-minute estimates have substantial loadings on one or both of these factors. The factors reflect the general positive intercorrelation of the 2-minute estimates, and appear to have resulted from consistent individual differences in such estimates.

However, before inquiring into the possible nature of such individual differences, it is necessary to ask why there are *two* factors involved rather than only one. The answer appears to lie in the fact that estimates made close together in the course of the experiment tend to correlate more highly than estimates more widely separated. This can readily be seen in the intercorrelations of the 2-minute time estimates (Appendix B): the correlations tend to be highest next to the principal diagonal, and to drop off toward the upper right-hand and lower left-hand corners. This form of correlation matrix has been described by Guttman (1954a) under the name of "simplex."[9] He notes that in a conventional factor analysis such a matrix tends to yield two factors, based on the clustering together of the earlier and later tests (Guttman, 1954a, p. 347). This indeed appears to have happened in our analysis. Factor I reflects the general intercorrelation of all the estimates, with the highest loadings on the later estimates in the series. Factor III's high loadings are on the estimates in the early part of the experiment (including the estimate of the first 20 minutes). Factors I and III have, therefore, been considered as a single factor, one which represents individual differences in the general level of estimates of the 2-minute interval. For convenience, it will be referred to hereafter simply as Factor I. The factor scores for "Factor I" are based on this combined factor.

It may be noted that such a factor need not be, and probably will not be, causally simple—various quite different conditions may jointly influence the over-all level of *S*'s estimates. General response tendencies —to overestimate time, give extreme responses, use round numbers, or the like—would be a possibility; however, these do not seem to be involved in a major way, for they ought to affect the short intervals as well, and overestimation of the short intervals does not load substantially on Factor I. However, any idiosyncratic notions *S*s may have as to how long a minute is would contribute to the intercorrelation among the 2-minute estimates, and hence to the loadings on this factor. The loading of the 20-minute estimate on this factor is consistent with this view.

Differences in ability, or practice in judging time intervals of this length, may also play a role since persons with low scores on this factor are closer to objective accuracy than persons with high scores. The negative correlations of Factors I and III with some of the performance measures suggest that ability may be involved to some extent, but the evidence for an ability factor is clearer in the case of Factor IV.

Another possible source of general intercorrelation of estimates would be differences between the experimental situation as a whole and the conditions under which *S* normally estimates time (assuming that these differences varied between individuals). Clues to such differences might lie in *S*'s ratings of the tasks, or in the personality measures.

As for the ratings, one difference[10] emerged: *S*s with high scores on Factor I tended to describe tasks loaded on the factor as less interesting than did *S*s with low scores. In other words, persons who overestimated these tasks tended also to

[9] In the circumstances with which Guttman is primarily concerned, the higher correlation between adjacent variables arises in a different way. It is interesting to note, however, that one of the empirical examples he cites (Guttman, 1954a, p. 288) appears to resemble the present case at least as closely as it does his theoretical model.

[10] This difference is significant at the .05 level by *t* test; however, this and subsequent significance figures must be regarded with some caution, since a certain advantage may be taken of chance when a few *t* tests are selected from a larger number on the basis of their significance.

rate them as less interesting. The first factor appears to reflect to some extent, then, individual differences in the degree of interest or involvement in the experiment as a whole.

A second kind of difference which might contribute to a general intercorrelation of estimates would be an emotional reaction to the experimental situation as a whole, such as anxiety, annoyance, or apathy. Insofar as such a reaction was a characteristic one for the individual, it might be expected to be also reflected in a difference in MMPI scores, on such scales as *Pt*, *Pd*, or *D*, between individuals with high and low scores on Factor I. No significant differences of this nature emerged. However, since the MMPI was filled out at a time different from that of the experiment proper, transient differences in mood remain as a possible source of consistent individual differences over the set of 2-minute estimates.

To summarize, Factor I is general to the 2-minute estimates. It appears to reflect the tendency of some individuals to estimate the 2-minute intervals as consistently longer or shorter than others do. To some extent this may be due to individual differences in the use of the unit of estimate (minute). A second determinant seems to be the degree of interest in the tasks, with the subjects who find the tasks generally boring tending to estimate them as longer.

Factor II. (See Table 5.) This factor appears to be determined primarily by the estimates of the short intervals, but its other loadings suggest possible further implications. The 2-minute tasks whose estimates load on Factor II were among the tasks most overestimated; the period of concentration on time was estimated longest of all.

TABLE 5

VARIABLES LOADED ON FACTOR II

No.	Variable	Loading
18	Estimate of 4 sec.	.78
17	Estimate of 1 sec.	.70
15	2-min. est., Concentration on time	.36
2	2-min. est., Writing 1's (1st)	.27
11	2-min. est., Writing 1's (2nd)	.26
22	No. of 1's written in 4 sec.	−.29

Since the short intervals were "empty" ones, and since the tasks of concentrating on the passage of time and writing the figure "1" repeatedly are conspicuously lacking in variety of content, Factor II could perhaps be described as an "overestimation of empty intervals" factor. However, it is possible that attention to the passage of time is the significant variable, and that the relative emptiness of the intervals is important mainly because it permits this to occur. The primary role of the short intervals in determining this factor seems in accord with this interpretation. For a 1-second interval, emptiness does not suggest much in the way of emotional reactions such as boredom or suspense, but what the subjects *were* presumably doing during the short intervals was attending very closely to the passage of time.

The negative loading of the number of 1's written suggests that persons who "filled up" the empty intervals more with their activity showed less tendency to overestimate them. The ratings of the three 2-minute tasks by persons with high and low scores on Factor II seem consistent with this. The high scorers—persons who overestimated the short intervals—rated these three tasks as significantly less satisfying than did the low scorers ($p < .001$).

There were no substantial differences in MMPI scores between persons with high and low scores on Factor II, which may offer some additional weight to an interpretation of this factor in terms of differences in attention to time, rather than in terms of emotional reactions to empty time.

To summarize, therefore, it appears that Factor II, in addition to having variance specific to the short estimates, reflects the overestimation of empty intervals—possibly due to a greater attention to the passage of time during them.

TABLE 6

VARIABLES LOADED ON FACTOR IV

No.	Variable	Loading
13	2-min. est., Difficult anagram	.42
11	2-min. est., Writing 1's (2nd)	.41
1	2-min. est., Introduction	.33
23	No. of questionnaire items in 2 min.	.31
25	Gottschaldt figures solutions	.28
12	2-min. est., Easy comparisons	.27
26	Amount of error, counting "the's"	−.46

Factor IV. (See Table 6.) This factor appears to load two groups of variables: time estimates on repeated tasks, and scores reflecting good performance on tests involving the ability to perceive analytically.

The *Difficult anagram, Writing 1's (2nd),* and *Easy comparisons* tasks represent tasks given earlier in the series and now repeated (with changes in difficulty level for the anagrams and comparisons). Persons who tended to estimate the second administration as relatively long tended also to perform well on the *Counting "the's"* task and the *Gottschaldt figures,* as well as completing a large number of questionnaire items in two minutes.

The *Introduction* estimate seems on the face of it rather out of place among estimates reflecting repeated trials. This loading may, however, be an artifact—it may simply reflect the fact that the brighter *S*s finished filling out the face sheet data early, and then had to wait for the slower ones, and judged the period long in consequence. (Barring the few *S*s who completed the *Gottschaldt figures,* this was the only activity where the element of finishing early could enter: the others were all of indefinite length.)

There were no significant differences in the ratings which persons high and low on Factor IV gave to the tasks best measuring that factor, nor in the changes of ratings from the first to the second administration of these tasks. This tends to exclude a fairly obvious hypothesis—namely, that the brighter *S*s tended to judge a repeated task as long because they found it relatively less interesting.

Nor were there significant MMPI differences between *S*s with high and low scores on Factor IV. The largest difference (which approaches the .05 level) is for the high *S*s to score higher on Barron's Ego Strength scale. This, if reliable, is consistent with their better performance on the ability measures—Barron (1953) reports a positive correlation of this scale with several measures of intelligence.

To summarize, Factor IV appears to reflect a tendency to estimate the second of two periods of a repeated activity as relatively long. Positive loadings of perceptual ability measures, and a failure of ratings of the tasks to discriminate, suggest that this factor is of an intellectual rather than an attitudinal kind, but its precise nature remains uncertain.

Factor V. (See Table 7.) The highest loadings on this factor are on the two tasks in which *S*s compared short time intervals, and the loadings are negative, indicating that the persons with high scores on this factor tended to be those who were less affected by the illusions which characterize these tasks.

There is some reason to suspect that an activity–passivity dimension may be involved here. The *S*s with high scores on this factor tended to write a large number of 1's, and to overestimate the three periods in which *S* played a predominantly passive

TABLE 7

VARIABLES LOADED ON FACTOR V

No.	Variable	Loading
8	2-min. est., Listening to reading	.36
22	No. of 1's written in 4 min.	.32
1	2-min. est., Introduction	.31
27	No. of persons in *S*'s group	.29
19	Estimate of 20 min.	.28
10	2-min. est., Interruption	.26
3	2-min. est., Easy anagram	.25
20	Negative time error, Diff. comp.	−.43
21	Amount of illusion, Accel.-decel.	−.43

role (*Listening to reading, Introduction,* and *Interruption*). It seems plausible that *Ss* preferring more active modes of judgment would be less subject to perceptual illusions than more passive *Ss*. It is not obvious, however, why the estimate of 20 minutes should be loaded on this factor, and the positive loading of the *Easy anagram* estimate is, if anything, rather contradictory to an active–passive interpretation. The loading of number of persons on such a factor had not been anticipated, but it does seem conceivable that in the larger groups there was a sharper contrast between *E*'s active role and the group's passive one.

The *Ss* high and low on Factor V were compared in terms of their ratings of the two tasks loading highest on this factor (*Listening to reading, Introduction*). The high *Ss* tended to judge the tasks as easier than the low *Ss* did ($p<.05$) and showed some tendency to rate the time as seeming to go more rapidly ($p<.10$).

The passive tasks are not overestimated, then, because they *seem* to be going more slowly for the active subjects. Possibly it is the difference from their usual attitude that is important: the change in level of involvement is greater for them when shifting from active to passive tasks than it is for the more generally passive subjects.

On an active–passive dimension, one would expect to find MMPI differences between high and low *Ss*. One would expect the passive *Ss* to be higher on the *Pt*, *Hy*, and *D* scales, and the active *Ss* higher on *Pd* and *Ma*. One might also expect to find the active *Ss* higher on Ego strength. The differences on *Pt*, *Hy*, *D*, and *Ma* are in the proper directions, with the first two near the .05 and .10 levels, respectively. The *Pd* and *Es* differences, although not large, are in the wrong direction for the hypothesis—the lows have slightly higher mean scores on these scales.

In general, then, although there is scattered evidence that Factor V reflects an active–passive dimension, its interpretation in these terms must remain tentative.

TABLE 8

VARIABLES LOADED ON FACTOR VI

No.	Variable	Loading
24	Easy anagram solutions	.33
7	2-min. est., Slow calculation	.30
23	No. of questionnaire items in 2 min.	.29
22	No. of 1's written in 4 min.	.28
19	Estimate of 20 min	−.30
28	Age	−.44

Factor VI. (See Table 8.) It was suspected that this factor reflected sex differences, since age and sex were known to be correlated in the sample (the males tended to be older, largely as a result of sex differences in enrollment in the classes from which the *Ss* were drawn. See Table 1.) The loadings on Factor VI were therefore compared with the correlations[11] between sex and each of the variables in the study. The r_{pb} between age and (female) sex was −.41, compared to the loading of −.44 of age on Factor VI. The other *r*'s tended to be low, but for each of the nine variables where either the factor loading or the r_{pb} was as high as .20, both the loading and the *r* were in the same direction. It seems reasonable to conclude, therefore, that sex differences were mainly responsible for the emergence of this factor. The factor does not seem to be of particular interest from the standpoint of time perception except in a negative sense, for only two time estimates are loaded on it, and neither is high. The positive loading of the scores on the two verbal tasks is consistent with the common finding of a slight female superiority in verbal ability.

Factor VII. (See Table 9.) Three of the five loadings on this factor involve the anagram tasks, and the factor may largely represent something fairly specific to those procedures. It does not seem advisable to attempt to give it any more general interpretation. It is of passing interest to note that both scores and estimates are loaded

[11] Point biserial *r*'s.

TABLE 9

VARIABLES LOADED ON FACTOR VII

No.	Variable	Loading
24	Easy anagram solutions	.43
13	2-min. est., Hard anagram	.26
2	2-min. est., Writing 1's (1st)	.26
3	2-min. est., Easy anagram	.25
14	2-min. est., Counting "the's"	−.39

in the same direction, i.e., *S*s who got higher scores also estimated the period as longer. It does not appear that this is in general true—the opposite effect occurred with the Gottschaldt figures; cf. Factor III (Table 4).

Factor VIII. (See Table 10.) This factor has loadings on a number of the 2-minute estimates, but its interpretation seems obscure. The tasks have little obviously in common either in their structure or in terms of *S*s' ratings of them. A factor score was computed, but high- and low-scoring *S*s did not differ significantly in terms of either task ratings or MMPI scores. The two highest loadings on Factor VIII are on estimates during the comparisons tasks, and variance specific to these tasks may have been instrumental in the emergence of this as a separate factor, but beyond that it will be left uninterpreted.

General comments. This interpretation of the eight rotated factors has left four which seem to be of particular relevance to time perception. One of the remaining factors was interpreted as an artifact due to constant presentation order, one as due to sex differences, one as mainly specific to the anagram tasks, and the fourth was not interpreted, although it appeared to load some variance specific to estimates of the psychophysical tasks.

TABLE 10

VARIABLES LOADED ON FACTOR VIII

No.	Variable	Loading
12	2-min. est., Easy comparisons	.44
4	2-min. est., Difficult comparisons	.35
11	2-min. est., Writing 1's (2nd)	.34
14	2-min. est., Counting "the's"	.30
19	Estimate of 20 min.	.30
7	2-min. est., Slow calculation	.29
8	2-min. est., Listening to reading	.26
16	2-min. est., Questionnaire	.25

One question should be raised concerning the four time perception factors. Three of them—Factors I, II, and V—appear to load variance specific to the long estimates, short estimates, and comparison tasks, respectively. However (except possibly for the first of these) each appears to reflect important common variance as well, and it is this which has mainly been taken into account in arriving at the interpretations given.

The important presence of specific variance is in some respects awkward theoretically. It need not challenge the meaningfulness—or the usefulness—of the present factors, but it does suggest the possibility of alternative solutions. One cannot be confident that exactly the same set of factors would have emerged from a factor analysis of the 2-minute estimates if an entirely different group of additional variables had been used.

The Questionnaire

The questionnaire items which correlated with each of the four time-perception factors at a significance level of .05 or better are listed below.[12] The items for each factor are listed approximately in decreasing order of significance.

Factor I. Persons scoring higher on this factor—those who in general overestimated the 2-minute intervals—agreed more often with the following items:

I have a one-track mind
I seem to be pressed for time more than most people
I have a poor memory for the past events in my life

[12] For an item with true and false responses equally divided, the biserial r which is just significant at the .05 level is .24. With more extreme divisions of responses it is higher.

I often find it hard to 'get going' on something
Often, although the days go slowly, the weeks and months seem to fly by
I haven't enough time to accomplish the things I most want to do
The future is too uncertain for a person to plan very far ahead
Sometimes I feel like I'm in a trance
I have a hard time remembering the dates things happened.

There were no items with which persons low on this factor agreed significantly more often.

The items which correlate with Factor I seem to relate to deficiencies in time perspective—to a failure to integrate the present with the past and future in the effective planning and carrying out of activities. The relationship is on the face of it a simple one: If the past and the future lack reality, the present activity looms larger.

A somewhat similar relationship has been reported in a factor-analytic study by Cattell and Gruen (1955), in which a number of time estimates were included in a battery of tests given to 11-year-old children. One of the resulting factors, which had its highest loadings on several time estimates, also loaded a measure of "unattainability of distant goals." (Other loadings on the factor were: poor arithmetic, errors in a complex reaction time experiment, and female sex.)

Factor II. Persons scoring higher on this factor—those who overestimated short intervals and monotonous tasks—agreed more often with the following items:

A period of a few minutes often seems like hours to me
I am often in a hurry
I have a hard time remembering the dates things happened
I daydream a good deal
I have many memories of childhood events that seem like they might have taken place only yesterday
When I wake up in the morning, it usually seems like I just went to sleep a few minutes before.

Persons scoring lower, agreed more often with:

My childhood days seem very unreal to me
My father is a rather dominant person
I sometimes think we would have been better off if clocks had never been invented
I usually have a pretty accurate idea what time it is.

The contrast here appears to be one between persons with an underdeveloped and an overdeveloped sense of the conventional scale of time. The high-scoring *S*s seem to view time in a much more flexible way: Minutes often "seem like hours"; childhood events seem like "only yesterday"; when they awake it seems like they have been asleep "only a few minutes." The low-scoring *S*s, on the other hand, say they usually have an accurate idea of time, but the psychological distance of childhood, the dominant father, and the resentment of clocks suggest oversocialization—that this was achieved at some cost.

It would seem indeed to follow that for the high-scoring *S*s there would be a great difference in the apparent length of time depending on whether or not its passage were being attended to, and for the low-scoring *S*s this effect would be minimal. However, the results are also consistent with other interpretations—one might expect many influences to have a greater effect on the high-scoring *S*s' perception of time.

Factor IV. Only one item was significantly related to this factor. Persons with higher scores on the factor—those who overestimated repeated tasks—tended to agree more often with the statement: I am easily bored. The implication of this is far from clear. They did not actually rate the tasks loading on this factor as more boring than the low-scoring *S*s did, nor did they differ in the change in their boredom ratings from an original to a repeated activity.

Perhaps the most relevant fact after all is that only the one item emerged from this analysis. This would appear to add weight to the view that Factor IV is largely independent of attitudinal and motivational factors, which are relatively well represented in the questionnaire, and is fairly specifically linked with the cognitive variables reflected in the performance scores.

Factor V. Persons scoring higher on this factor—those who were less subject to time

illusions—agreed more often with the following items:

I have a pretty definite idea what I will be doing next summer
I usually have a pretty accurate idea what time it is
I'm pretty good at saving time
I have great faith in the future.

Persons scoring lower, agreed more often with these items:

I become impatient if I have to wait five minutes for someone
I have a hard time getting things done without deadlines.

The high items appear to reflect a feeling of confident control of time. The low end of the dimension is less positively defined, but both items suggest an individual at the mercy of external events.

This appears reasonably consistent with the active–passive interpretation suggested earlier for this factor.

Discussion and Conclusions

The major purpose of the investigation was to examine the nature of the influences that various activities have on the apparent length of time during them. A factor-analytic design was employed with the aim of identifying the main ways in which different activities influence the perception of moderate intervals of time.

The 2-Minute Intervals

What, then, proved to be the major variables related to the perception of moderate intervals of time in this investigation?

The first such variable seems to have been the interest or boredom which the tasks aroused in *S*s. This variable appears as a partial determinant of general under- or overestimation of time, as reflected in Factor I. Persons who found the tasks in general to be less interesting tended also to perceive them as longer.

The second variable is related to the overestimation of intervals lacking in variety of content. It appears that this might be due to greater attention given to the passage of time during such periods. The persons who overestimated these periods most showed evidence on the questionnaire that their perception of time in everyday situations is relatively fluid. The persons who overestimated these periods least indicated a better regulated sense of time in other situations. This regulation may in part be mediated by compensatory activity in boring situations—the latter *S*s wrote more I's, and found the monotonous tasks relatively satisfying.

A third variable concerns the over- or underestimation of repeated activities. This was related to measures of perceptual ability: The more able *S*s tended to estimate repeated tasks as relatively longer, the less able *S*s as relatively shorter. This was not accompanied by any differences in the ratings of the repeated tasks—for example, it did not appear that the more able *S*s found the repetition more boring, although they *said* they became easily bored.

A fourth variable is *S*'s activity or passivity during a task. Factor V seems to reflect this to some extent. The three periods in which *S* predominantly watched or listened to *E*, as opposed to working at some task, were all loaded on this factor. The *S*s who most overestimated the passive periods tended to rate them as relatively easier. It was suggested that for the more active persons, the passive periods differed more sharply from the active ones. Scores on the time illusions, performance scores, and scores on the MMPI appeared consistent with the interpretation of Factor V as reflecting an active–passive dimension, although the evidence was not entirely clear-cut. The questionnaire results seemed also to support this interpretation.

A fifth variable—time perspective—appeared in the questionnaire items related to Factor I. Individuals for whom past and future were subjectively less real, overestimated the time occupied by present activity. Since this is not an effect of the activity as such, but rather relates to individual differences in the frame of reference of time judgments, it is of secondary interest to the present discussion, which will continue mainly in terms of the first four variables.

We may consider these four variables as constituting four sources of overestimation

of time: time may seem long during an interval because the activity is boring, because attention is being paid to the passage of time, because the activity is unfamiliar, or because *S* is relatively passive. Obviously many situations in which time is overestimated will involve more than one of these variables. For example, waiting for someone who is late for an appointment might involve most or all of these factors.

Are these variables adequate to account for the results of the experiments reported in the literature on moderate [13] time intervals, or need additional factors be considered?

The experimental results prior to 1930, which are summarized in Table 11, can fairly easily be handled in these terms. The active–passive distinction appears most marked, but many of the differences presumably would involve an interesting–boring, or an attention-to-time dimension as well. One or both of the latter dimensions is required to handle Axel's (1924) results: overestimation of active tasks of a repetitious sort (tapping and writing i's).

The case of pain presents an interesting paradox. Enduring pain is something that is ordinarily thought of as making time seem long. And yet in experiments, periods of pain have either been rather slightly

[13] The writer classifies as short those intervals falling within the "conscious present" (up to six seconds or so), and as moderate, those from this length up to about 10 minutes.

TABLE 11

SUMMARY OF EARLY EXPERIMENTS ON THE ESTIMATION OF MODERATE TIME INTERVALS

Experimenter	Estimated as Relatively Long	Estimated as Relatively Short
MacDougall (1904)	listening to reading waiting in idleness	marking m's estimating time
Yerkes & Urban (1906)	idleness listening to reading estimating time	writing from dictation
Spencer (1921)	listening to prose listening to poetry reading prose aloud reading poetry aloud	writing from dictation
Sturt (1923)	looking out window reading aloud	listening to clock pain
Axel (1924)	estimating time tapping writing 1's	cancellation analogies number series adding 7's
Swift & McGeoch (1925)	idleness listening to reading	copying ns. syllables copying fiction copying catalog
Gulliksen (1927)	resting experiencing fatigue hearing slow metronome hearing fast metronome pain	mirror reading writing from dictation long division
Whitely & Anderson (1930)	empty interval listening to buzzer	listening to music

overestimated (Gulliksen, 1927) or actually underestimated (Sturt, 1923). The critical difference would seem to be that in these experiments the *S*s were deliberately inflicting temporary pain on themselves, thus transforming the pain from a dull, passive experience to an active, challenging one.

The only cases in Table 11 which seem to present a serious problem to the present set of variables are the two instances where reading aloud by *S* was overestimated. This seems, at least superficially, to be an activity which is interesting rather than boring, active rather than passive, and filled rather than empty. Some novelty may be involved, but it is not obvious that this would be sufficient to outweigh the other factors. Two hypotheses suggest themselves. One is that reading really does involve a strong passive element—after all, it is always the author who decides what is coming next. The other is that in literary narrative the time scale is usually condensed—events which occupy a given period of time are reported in a shorter period of reading time. If *S*'s estimates are influenced by the time scale of what he is reading, the result will tend to be "overestimation" of the objective interval.

In the more recent literature on the estimation of moderate time intervals,[14] the present set of factors seems capable of dealing with many of the findings, but there are some new issues raised.

Our factor relative to repeated tasks appears to represent the similar effect reported by Harton (1938, 1939a), Eson and Kafka (1952), and Falk and Bindra (1954). Our interesting–boring dimension readily subsumes Harton's (1938) effect of difficulty, if his difficult tasks are assumed to have been more interesting to his *S*s.

Experiments concerning stress and anxiety present more of a problem (Falk & Bindra, 1954; Harton, 1939a; Henrikson, 1948; Simmel;[15] Smith, Wing, & Jerison, 1955). Although our experimental situation was not conducive to extreme degrees of stress, the activities were intended to vary along this dimension. Some of the tasks were given as "tests" involving time pressure; others were neutral in this regard; some of the activities were designed to be pleasant and relaxing. Surely the subjects were differentially prone to anxiety under pressure,[16] but no stress factor emerged from their estimates.

In the experiments reported in the literature in which time was judged longer under stress, the effect appears in connection with repeated trials, and it is possible that it was indirect. In Falk and Bindra's (1954) experiment, for example, the occasional shock may have acted mainly by counteracting the effects (of habituation, or whatever) which led to increasing underestimation over their series of trials. Correspondingly, in Simmel's experiment[17] most of the obtained difference was due to the failure of his experimental group to show a decline in its estimates during a second period, one in which ego-involving instructions were given. The experiment of Smith et al. (1955) involved a long series of trials, and the stress imposed by a higher noise level may have worked in a fashion similar to Falk and Bindra's shock. Harton's (1939a) results were also obtained over repeated trials. In the one experiment in which repeated trials were *not* involved (Henrikson, 1948), the results were actually in the opposite direction (time was underestimated during public speaking).

There are numerous instances in everyday experience where time seems long under stress. Such instances may conceivably be explained in similar fashion; i.e., the slow passage of time in stressful situations

[14] For a more complete review, see Loehlin (1957, pp. 11–21).

[15] E. C. Simmel. The effect of stress-producing instructions on time perception in a group test situation. Personal communication, 1956.

[16] The σ of MMPI *Pt* in our sample was 15.4. Goodstein (1954) reports a median *Pt* σ of 10.3 in eight studies of college males.

[17] See Footnote 15.

may result from a failure of habituated modes of response in such situations. However, others of the factors may be involved as well. Boredom hardly seems a likely candidate, but an inhibition of activity by anxiety would seem to be a possibility, or an acute attention to the passage of time in the anticipation of threatening events. At any rate, the influence of stress on time perception stands as a matter in need of closer experimental analysis.

Another phenomenon which has been described in the literature is the increasing underestimation of time as a goal is approached (Hindle, 1951). The present investigation was not well suited to detecting this since, for other reasons, it was desirable to make most of the tasks of indefinite length, i.e., comparable to Hindle's "no goal" condition. Consequently no safe conclusion can be drawn as to whether or not such a phenomenon could be accounted for by the present factors. Certainly one would suppose that the interest of a task and the level of activity might rise as a goal was neared, but so might attention to time. One would also need to take into account the influence of a goal on the time perspectives involved.

The results of the present investigation bear on another topic which has been the subject of some discussion in the literature —that of sex differences in the estimation of time. Several of the earlier studies (Axel, 1924; Gulliksen, 1927; MacDougall, 1904; Yerkes & Urban, 1906) reported a greater overestimation of time by women than by men. In more recent work, this difference has not, as a rule, been found (Gilliland & Humphreys, 1943; Harton, 1939b; Swift & McGeoch, 1925). The present study disclosed a factor of sex differences (Factor VI), but its loadings were mostly on performance scores, rather than time estimates. On the other factors, male and female *Ss* were about equally distributed between highs and lows, as Table 12 shows. Thus the present investigation tends to agree with the other more recent studies which have failed to find the sex differences in time estimation reported in the earlier experiments. It has been suggested that changes in the role of women in the American culture have been responsible for the disappearance of this difference (Gilliland, Hofeld, & Eckstrand, 1946).

TABLE 12

SEX OF *Ss* WITH HIGH AND LOW FACTOR SCORES

Group	Factor			
	I	II	IV	V
High scorers				
Men	6	6	9	6
Women	22	22	19	22
Low scorers				
Men	5	9	6	9
Women	23	19	22	19

It is possible that the sex difference reported in the early studies may still be found among children. In the Cattell and Gruen (1955) factorial study of 11-year-olds mentioned earlier, female sex was loaded on the same factor as high time estimates. However, Gilliland and Humphreys (1943) failed to find significant sex differences in time estimation among 48 fifth-grade children, so the issue remains doubtful.

Short Interval Estimates and Other Time Judgments

Let us turn now to the second main question to which the present investigation was directed: To what extent do the obtained factors apply to estimates of shorter and longer intervals, and other time judgment phenomena?

Perhaps the most striking feature of the results in this respect is the absence of a general time estimation factor. Although the first factor loaded all the 2-minute estimates and the 20-minute estimate, the short interval estimates came out on a separate factor.[18] People who overestimate minutes

[18] An oblique factor solution would probably have shown a slight degree of relationship between the two factors. Their factor scores correlated .14.

do not necessarily overestimate seconds. The subjective scale of time is apparently not a highly integrated dimension for most of our *S*s.

Note that this does not imply that moderate and short intervals have nothing in common. Several 2-minute estimates do load on Factor II, and meaningfully so. But the influences which set the *general* level of an individual's estimates in the 2-minute periods do not appear to have acted in the same way on his estimates of the shorter intervals. In some respects, of course, this is not surprising. The degree of general interest or boredom contributed to Factor I, but it seems reasonable to suppose that variations in boredom will not be great for periods as short as one and four seconds.

Are there any data in the literature which bear on this relative independence of moderate and short interval estimates?

A general tendency toward positive intercorrelation of estimates of moderate intervals (½ minute to 3 minutes) is present in Adler's (1954) data. Clausen (1950) has reported high intercorrelations of estimates of intervals from 5 seconds to 15 seconds. (His subjects were schizophrenics, however, and some caution must be exercised in generalizing to other samples. Eccentricities of judgment—e.g., a subject who consistently estimates a period of seconds as several hours—could inflate correlations considerably in such a group.) Eson and Kafka (1952) report some correlations between a 15-second and a 2-minute interval. These *r*'s ranged from .69 to .73 under four conditions. This is the only case known to the writer in which correlations between estimates of intervals this far apart are reported—although 15 seconds is really not in the short interval class. These *r*'s are for estimates made *under the same conditions* for the 15-second and the 2-minute intervals: the case is perhaps more closely analogous to the relationship of short and moderate estimates on our Factor II than to the relationship between our Factors I and II.

Until more complete evidence is forthcoming, then, our tentative conclusion will be that the estimation of moderate and short intervals of time proceeds in substantially different ways, but that at least some content conditions affect both similarly.

The comparison and estimation of short intervals also came out on separate factors. This result is in line with earlier findings: Clausen (1950) found the reproduction method (which involves comparison) to give rather low correlations with results from two methods involving estimation. Although a negative time error in comparing time intervals has traditionally been called an "overestimation" of time, it would appear that it is at least a different kind of overestimation than that which occurs with absolute estimates.

The fact that both of the comparison procedures would have essentially all of their common variance on a single factor was somewhat unexpected. Although the general form of the stimulus presentation and judgment was the same in both cases, response tendencies such as responding at random, alternation of responses, or preference for one or the other of the two judgments, would have had quite different effects on the scores on the two variables. Both of the tasks, however, involved "illusions"—the apparent lengthening of the second interval and of the decelerating sound pattern. Hence, some aspect of *S*'s attitude which would make him more or less subject to such illusions seems a likely explanation for the similar relationships of these two measures to the other variables. In the light of the rest of the loadings on Factor V, it was suggested that this common aspect might be a relatively active or passive perceptual attitude.

Some evidence in support of such a view is offered in the work of Holzman (1954) and of Holzman and Klein (1950, 1954). Their "levelers" displayed larger time errors in visual brightness, lifted weights, and auditory loudness than their "sharpeners" did, and also displayed generally passive personality characteristics. Woodrow (1935), on the basis of his work with practice effects, has argued that time errors in time judgment are closely related to those in other modalities.

Conclusion: Method and Results

In evaluating the results of this investigation, which represents a somewhat novel approach to an old problem, some comment is necessary concerning several limitations of our study, some of which are specific to it, some inherent in this use of the factor-analytic method, and some, general methodological limitations common to most psychological research today.

1. Neither the situations nor the persons represent truly random samples from clearly defined populations, making generalizations to some extent hazardous. These difficulties exist, of course, in most psychological research (Brunswik, 1949). Factor analysis, to the extent that it usually employs a greater variety of situational variables than most techniques, is perhaps less subject to this stricture than they. As for the present study, it at least used an array of situations considerably larger than that of any previous investigation in this area known to the writer.

2. Correlations depend on individual differences. As mentioned earlier, a situational variable which tends to be uniform in its effects may have a relatively slight influence on the correlations while having an important effect on the estimates themselves. Something of the kind may have happened in the present study, with the variable "interest vs. boredom," which was markedly related to differences between mean estimates,[19] but did not appear to carry as much weight in determining the factors as might have been expected.

3. As discussed in an earlier section, various sources of common variance somewhat irrelevant to the main purposes of this study played a significant role in the factor resolution. While this must be regarded as a methodological fault, it does not seem to have prevented the obtaining of meaningful factors.

4. The interpretation of factors has at best its subjective and intuitive aspects—as does the interpretation of the results of most experiments, if more than trivial conclusions are drawn. In the present investigation, provision was made for obtaining additional evidence—*S*s' ratings of the tasks and MMPI scores—to reduce the risks inherent in this procedure. Also, the relationships of the factors to the items from the time questionnaire provided additional information concerning the adequacy of these interpretations.

On the credit side it appears that, despite the above limitations, the investigation proved fairly successful. Variables were isolated which seemed to relate meaningfully both to the results of earlier investigations and to our *S*s' statements about their behavior and perception relevant to time in everyday situations. Some light was shed on methodological questions: the results yielded some information concerning the extent to which, and the conditions under which, results obtained with different methods of measurement, or involving different time intervals, can be expected to reflect the same underlying variables. Finally, at least scattered information was obtained relevant to the integration of time perception into the larger system of personality.

For the reasons discussed, it cannot be claimed that the set of variables isolated in this study represents a definitive description of the variables affecting time perception, yet the present study appears to represent a step in that direction, and one taken from a broader empirical base than experimental investigations in this area have used in the past.

Summary

Previous investigators have shown that estimates of time during periods occupied with different activities will be influenced by the content of the intervals, but little agreement exists as to the important variables involved.

This investigation sought to isolate such variables by a factor analysis of time esti-

[19] The Spearman rank-order correlation between mean rating of "boring" and mean time estimate, over the sixteen 2-minute activities, was +.61. An analysis of the relationships between estimates and ratings may be found in Loehlin (1957, pp. 73–78).

mates made under a number of conditions selected to be representative of those used by earlier writers.

One hundred and five college students made estimates of the apparent duration of sixteen 2-minute activities. In addition, they (*a*) rated each activity on several dimensions, (*b*) made estimates of shorter and longer intervals, (*c*) made judgments of short time intervals by comparison methods, and (*d*) completed a questionnaire concerning their perception of and attitudes toward time in everyday situations. Seventy-four of them also completed the MMPI.

The 16 time estimates plus 12 additional measures were intercorrelated and factored by the principal axes method. Seven of eight rotated factors were interpreted. The main variables contributing to the apparent length of the time intervals appeared to be:

1. interest vs. boredom
2. filled vs. empty intervals (attention to time?)
3. repetition of an activity
4. activity vs. passivity

A factor of stress or anxiety was suggested by previous work, but not found. A factor of sex differences was obtained, but little of its variance was on time estimates.

Evidence from the ratings of the activities and the MMPI scores was used in interpreting the factors; evidence from the time perception questionnaire in general supported and supplemented the interpretations.

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APPENDIX A

Means and Standard Deviations of the Variables

No.	Variable	Units	Mean	*SD*
1	2-min. est., Introduction	Secs/10	15.6	6.4
2	2-min. est., Writing 1's (1st)	Secs/10	19.8	7.1
3	2-min. est., Easy anagram	Secs/10	16.2	7.1
4	2-min. est., Difficult comparisons	Secs/10	17.2	7.3
5	2-min. est., Gottschaldt practice	Secs/10	16.4	8.2
6	2-min. est., Gottschaldt test	Secs/10	15.1	6.1
7	2-min. est., Slow calculation	Secs/10	16.8	7.7
8	2-min. est., Listening to reading	Secs/10	15.7	7.2
9	2-min. est., Pleasant thoughts	Secs/10	20.1	7.8
10	2-min. est., Interruption	Secs/10	14.3	6.2
11	2-min. est., Writing 1's (2nd)	Secs/10	20.5	7.0
12	2-min. est., Easy comparisons	Secs/10	15.6	6.7
13	2-min. est., Hard anagram	Secs/10	13.9	5.7
14	2-min. est., Counting "the's"	Secs/10	15.3	7.1
15	2-min. est., Concentration on time	Secs/10	23.6	9.9
16	2-min. est., Questionnaire	Secs/10	13.1	6.7
17	Estimate of 1 sec.	Sec. × 10	6.9	4.7
18	Estimate of 4 sec.	Sec. × 10	39.7	19.5
19	Estimate of 20 min.	Min.	15.9	6.6
20	Neg. time error, Diff. comp.	Responses "2"	9.1	2.4
21	Illusion, Accel.-decel.	Trials Dec. > Acc.	8.6	1.9
22	1's written in 4 min.	No./10	61.9	15.8
23	Questionnaire items in 2 min.		25.0	5.6
24	Easy anagram solutions		16.5	5.0
25	Gottschaldt figures solutions		9.1	4.6
26	Error, counting "the's"		8.1	4.7
27	Persons in *S*'s group		5.5	2.1
28	Age of *S*	Yr.	19.4	1.1

APPENDIX B

Intercorrelation Matrix

Var.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	Communality Estimate
1		17	30	16	25	32	18	18	16	32	26	15	15	18	08	15	00	06	29	−16	−13	−01	21	−12	07	−12	02	−03	38
2	17		41	36	30	38	19	24	19	16	34	15	16	06	22	25	12	28	25	−06	−11	−11	−10	−02	01	01	11	−03	50
3	30	41		36	47	47	20	32	35	32	32	42	44	26	18	35	17	11	22	−10	−06	12	−02	−13	−05	02	07	15	56
4	16	36	36		47	44	56	33	30	30	37	46	38	45	39	44	05	12	30	00	00	07	−05	−09	−12	−03	02	−03	55
5	25	30	47	47		60	34	18	28	25	33	31	38	40	39	27	09	15	28	05	−11	−05	−09	−22	−16	03	00	13	62
6	32	38	47	44	60		35	22	31	25	25	29	34	33	25	32	−02	00	33	−09	−10	15	18	−06	−03	−05	05	05	59
7	18	19	20	56	34	35		47	36	27	23	44	38	49	30	42	−05	01	03	03	01	12	−06	−10	05	−08	−05	00	57
8	18	24	32	33	18	22	47		32	29	22	32	36	42	20	32	12	16	13	−04	−17	12	−13	−24	08	01	15	08	45
9	16	19	35	30	28	31	36	32		38	31	40	46	36	49	31	05	11	−03	−02	05	14	−26	−29	12	−12	03	16	53
10	32	16	32	30	25	25	27	29	38		23	39	45	38	30	38	01	10	06	−09	−05	18	−14	−18	18	−10	07	−03	46
11	26	34	32	37	33	25	23	22	31	23		54	56	38	29	26	20	28	22	02	03	−02	−03	−10	06	−07	−04	01	59
12	15	15	42	46	31	29	44	32	40	39	54		53	57	38	41	10	11	18	06	11	−02	−07	−20	−04	−12	−02	10	62
13	15	16	44	38	38	34	38	36	46	45	56	53		39	33	31	01	07	−03	09	−04	15	−11	−01	15	−14	−07	07	65
14	18	06	26	45	40	33	49	42	36	38	38	57	39		47	53	05	06	16	01	00	05	−12	−36	12	−08	07	−04	66
15	08	22	18	39	39	25	30	20	49	30	29	38	33	47		36	18	37	−04	06	08	−16	−17	−33	01	−01	−03	−14	58
16	15	25	35	44	27	32	42	32	31	38	26	41	31	53	36		02	13	10	−01	01	05	01	−14	−06	11	09	05	52
17	00	12	17	05	09	−02	−05	12	05	01	20	10	01	05	18	02		62	00	01	−08	−16	−06	−25	−04	08	−10	−07	49
18	06	28	11	12	15	00	01	16	11	10	28	11	07	06	37	13	62		−01	03	−06	−17	00	−20	00	−07	−07	−04	57
19	29	25	22	30	28	33	03	13	−03	06	22	18	−03	16	−04	10	00	−01		−16	−17	−07	00	−13	−19	−08	14	10	43
20	−16	−06	−10	00	05	−09	03	−04	−02	−09	02	06	09	01	06	−01	01	03	−16		22	−23	−12	−08	12	19	−07	09	24
21	−13	−11	−06	00	−11	−10	01	−17	05	−05	03	11	−04	00	08	01	−08	−06	−17	22		−13	−01	−14	−06	04	−10	−03	24
22	−01	−11	12	07	−05	15	12	12	14	18	−02	−02	15	05	−16	05	−16	−17	−07	−23	−13		08	19	−04	−05	12	−08	34
23	21	−10	−02	−05	−09	18	−06	−13	−26	−14	−03	−07	−11	−12	−17	01	−06	00	00	−12	−01	08		30	00	−17	04	−11	39
24	−12	−02	−13	−09	−22	−06	−10	−24	−29	−18	−10	−20	−01	−36	−33	−14	−25	−20	−13	−08	−14	19	30		−08	−17	−02	−15	46
25	07	01	−05	−12	−16	−03	05	08	12	18	06	−04	15	12	01	−06	−04	00	−19	12	−06	−04	00	−08		−11	00	05	31
26	−12	01	02	−03	03	−05	−08	01	−12	−10	−07	−12	−14	−08	−01	11	08	−07	−08	19	04	−05	−17	−17	−11		−05	−11	31
27	02	11	07	02	00	05	−05	15	03	07	−04	−02	−07	07	−03	09	−10	−07	14	−07	−10	12	04	−02	00	−05		−02	14
28	−03	−03	15	−03	13	05	00	08	16	−03	01	10	07	−04	−14	05	−07	−04	10	09	−03	−08	−11	−15	05	−11	−02		29

APPENDIX C

Unrotated Factor Loadings

Variable	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1	35	−25	20	14	13	−04	29	16	−03	15	03	04
2	43	−05	40	01	01	−02	−24	−01	−31	−01	24	−10
3	60	−17	21	02	10	−20	−20	−01	17	18	−00	−14
4	67	−11	04	−17	−20	17	−06	−10	−08	−12	02	00
5	63	−07	24	−28	−08	−14	−06	22	04	−05	−18	18
6	59	−38	20	−13	−08	−04	−04	26	−02	04	−12	−01
7	60	−10	−27	−08	−11	22	−04	−08	−22	−08	−21	−02
8	53	−00	−08	06	29	15	−08	−24	−15	04	−14	01
9	59	12	−24	08	18	−13	−12	18	06	−18	05	−14
10	54	−06	−19	20	21	03	02	12	07	09	15	04
11	59	09	12	22	−24	−22	10	−19	01	04	17	14
12	69	07	−17	02	−19	−11	16	−24	16	−00	04	−08
13	66	−04	−27	27	−15	−27	−16	04	03	04	−02	15
14	69	07	−26	−10	04	20	29	−05	04	03	−04	11
15	57	39	−04	−02	−10	18	01	31	01	−16	11	−01
16	59	−02	−09	−11	−02	25	−03	−06	02	20	05	−21
17	16	48	42	23	04	09	−05	−10	14	05	−18	03
18	26	49	44	33	−02	14	−02	−01	−02	−06	−10	−08
19	27	−28	40	−25	12	−08	26	−18	00	−11	11	07
20	−02	31	−16	−18	−20	−18	−04	−00	−18	18	−08	02
21	−05	23	−21	−16	−26	−07	08	05	08	07	12	−21
22	06	−39	−22	18	12	16	−23	−02	23	−03	−05	05
23	−13	−36	18	23	−27	14	23	10	02	18	−15	−16
24	−31	−44	−01	26	−35	04	−21	−06	−08	−05	03	00
25	03	08	−24	29	18	−13	12	12	−32	15	−02	04
26	−08	20	04	−33	04	11	−25	−02	05	34	06	14
27	05	−17	03	−03	23	11	02	−06	−04	00	14	−08
28	07	−01	−04	−13	18	−42	02	−11	−04	−07	−22	−22

APPENDIX D

Rotating Matrix

Factor	1	2	3	4	5	6	7	8
1	86	19	−36	−09	16	−10	−18	13
2	14	69	58	36	−05	20	−04	−01
3	33	−40	61	−36	−33	−01	08	34
4	18	−22	−05	69	−22	−45	43	09
5	15	−45	26	27	73	28	−04	−12
6	06	−18	−28	31	−41	75	−10	21
7	−03	−22	12	24	−25	−27	−84	−21
8	25	−08	03	−11	−28	16	22	−88

APPENDIX E

Rotated Factor Loadings

Variable	I	II	III	IV	V	VI	VII	VIII
1	16	02	32	33	31	−03	−20	−02
2	26	27	38	−02	21	−07	26	07
3	48	06	34	13	25	−16	25	07
4	50	03	38	−04	03	19	04	35
5	51	05	58	00	−01	−12	02	−01
6	41	−12	63	13	18	07	07	−02
7	56	−12	11	−01	04	30	−03	29
8	49	07	−07	−05	36	02	00	26
9	70	02	−04	13	07	−02	00	−13
10	55	−01	−01	22	26	12	−08	−04
11	40	26	18	41	−08	−06	10	34
12	59	04	08	27	−11	01	−06	44
13	67	−04	02	42	−06	09	26	06
14	64	−02	07	07	06	16	−39	30
15	58	36	15	−02	−17	21	−21	−10
16	52	03	17	−09	11	22	−08	25
17	05	70	−02	−02	05	−09	02	07
18	11	78	04	08	05	02	00	04
19	01	−06	46	02	28	−30	−15	30
20	11	03	−10	−08	−43	−12	00	00
21	05	−03	−07	−03	−43	02	−11	02
22	08	−29	−09	03	32	28	22	−02
23	−35	−05	27	31	07	29	−02	04
24	−40	−22	05	18	−01	33	43	04
25	14	−02	−28	28	06	−01	−11	−19
26	02	06	00	−46	−11	−07	06	−03
27	02	−09	02	−07	29	−01	−06	04
28	14	−16	−04	08	00	−44	04	02